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MEASUREMENT OF ELECTROSTATIC FIELD STRENGTH AT THE
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by
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MEASUREMENT OF ELECTROSTATIC FIELD STRENGTH AT THE
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by G. L. Gdalevich

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A rocket flight in the ionosphere is accompanied by perturbation of the medium near its surface. One of the causes of such a perturbation lies in rocket's electrostatic charge. The interaction of this charge with the surrounding medium's charged particles is of interest for a series of problems, in particular for ionosphere measurements carried out with the aid of rockets. Therefore, the measurement of electrostatic field strength at the surface of a rocket flying through the ionosphere has a scientific and practical value.

Such measurements have been conducted in 1957-1958 near the surface of vertically-launched geophysical rockets of the USSR Academy of Sciences. In these experiments the electrostatic fluxmeter method was applied [1]. The fluxmeter's measuring and screen plates were

* Izmereniya napryazhennosti elektrostatičeskogo polya u poverkhnosti letyashchey v ionosfere rakety.

constituted by flat panels with six uniformly-disposed indentations in the form of sectors. The distance between the plates was chosen to be of 3 mm. The electric motor, used for the rotation of the screen plate, had a stabilized speed of rotation set at 9000 revol./min. Two electrostatic fluxmeters were installed at diametrically-opposed points of the cylindrical part of rocket's frame. The voltage generated by them is proportional to electrostatic field strength and is fed to a measuring circuit and the registered values are then telemetered to Earth with the aid of an appropriate radiotelemetric device.

The utilization of two fluxmeters allows in principle the separation of the field strength, induced by the body's own charge, from the component of the outer electrostatic field strength in the direction of the straight line between the points of installation of the two fluxmeters [1].

The measurement of the strength of the electrostatic field at the surface of a rocket flying in the ionosphere is complicated by the presence of constant currents, modulated by the rotation of the screen plate and flowing over the measuring plate. These currents are induced by medium's free charged particles and by the photoeffect stemming from solar ultraviolet radiation.

One of the peculiarities of the measuring circuit is the simultaneous utilization of the automatic sensitivity switch and synchronous detector. This permitted the broadening of the measurement range and

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the ascertaining whether the variations of the output signal are caused by the measured (working) current, induced at the expense of the electrostatic field at rocket's surface, or by the modulated constant currents ("interference currents"). The synchronous detector weakens by about 5 times the effect upon the output signals of interference currents. At the same time, interference currents exert an effect on the automatic sensitivity switch just as the working currents do. That is why, whenever the input signal, measured by readings at the input at the instant of sensitivity switching, is 5 times smaller than the signal for which switching must take place, the measured voltage values are determined by the interference currents and not by working currents. Prior to its switching the greatest circuit sensitivity was such, that to a voltage of 0.1 v at the output corresponded a field strength $E = 0.2 \text{ v/cm}$. The sensitivity switching must have taken place for $E = 6 \text{ v/cm}$ in case of absence of interference currents.

The first of the described experiments was conducted on 9 September 1957 at 19 54 hours, after sunset after -6° dipping, which corresponds to a terrestrial shade height of about 30 km. During its flight in the ionosphere the rocket was not stabilized and could spin. The second experiment was carried out on 21 February 1958 at 12 40 hours. During this experiment the rocket was stabilized during its total flight time. Unfortunately, no results of measurements near the summit of the trajectory were obtained in this experiment.

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The third experiment was conducted on 27 August 1958 at 08 06 hours. As in the preceding one, the rocket was stabilized at time of its flight through the ionosphere.

The most interesting result obtained at certain heights in all the three experiments was in the mutual difference in the strengths of the electrostatic field, measured simultaneously by the two fluxmeters. This distinction may have been either caused by experiment errors linked with interference currents, or by the true difference in the electrostatic field strength at points where fluxmeters were installed. This implies that at spots where fluxmeters are installed the thicknesses of the volume charge layer surrounding the rocket are different.

As was shown by laboratory tests of the apparatus, the maximum mean-square error of the device for the measured values of $E \leq 3$ v/cm does not exceed 0.6 v/cm. Thus, when considering voltage differences exceeding 1.2 v/cm, errors stemming from the device may be disregarded.

Interference currents may be induced by: a) rocket motion, causing the inequality of charged particle fluxes on measuring plates of the two fluxmeters; b) photoemission from measuring plates under the effect of ultraviolet and X-ray emissions of the Sun; c) medium motions, linked with ionospheric winds; d) presence of the outer electrostatic field. The same causes may create differences in the electrostatic field strengths near both fluxmeters, i. e. they may induce "interference current" discrepancies, according to the above-adopted terminology.

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Therefore, the difference in the strength of the electrostatic field, simultaneously measured with the two fluxmeters, is the result of the true difference in these strengths at spots where fluxmeters are installed only in the case when the "working" currents exceed considerably the interference currents.

Analysis of the sensitivity switch operation shows that with the exception of a few rejections, the value of the interference current density did not exceed $5 \cdot 10^{-10} \text{ a} \cdot \text{cm}^{-2}$ in the results of the experiments of 21 February 1958 (250—280 km altitude range in the ascending branch of the trajectory) and of 27 August 1958 (350—415 km heights) as may be seen in Fig. 3 below, and the fundamental part of the measured values is linked with the true values of electrostatic field strength at the surface of the rocket flying in the ionosphere.

Presented are in Fig. 1 and 2 the results of measurements near the summits of the trajectories obtained on 9 September 1957 and on 27 August 1958. The following designations apply to all the figures next page: 1, 2 — results of measurements of one fluxmeter, respectively during ascent and descent of the rocket; 3 — 4 indicate the same for the other fluxmeter. All the effects, linked with rocket motion, are entirely absent at the summit of the trajectory and are small near it. That is why, the discrepancy of fluxmeter-measured values of strengths, plotted in Fig. 1 and 2, cannot be explained by the effects related to rocket's motion.

In Fig. 3 we brought out the results obtained in the experiment of 27 August 1958. As may be seen from that diagram, the difference in

the values of the voltages measured during the flight changes the value and even the sign, although the disposition of fluxmeters relative to the Sun did not vary during the whole flight.

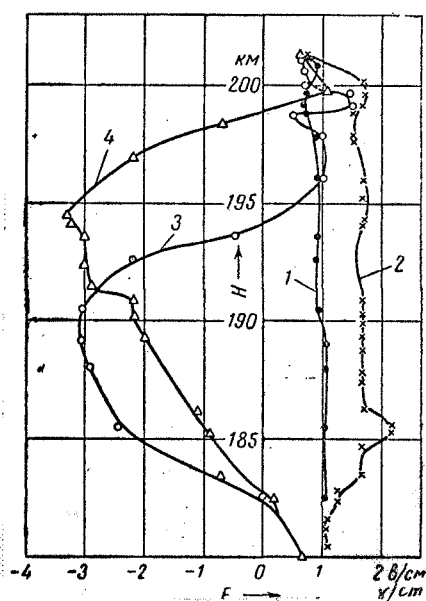


Fig. 1

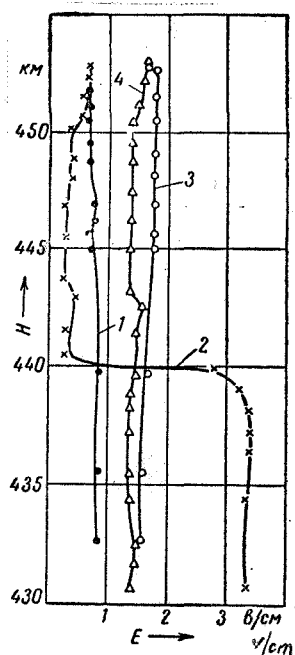


Fig. 2

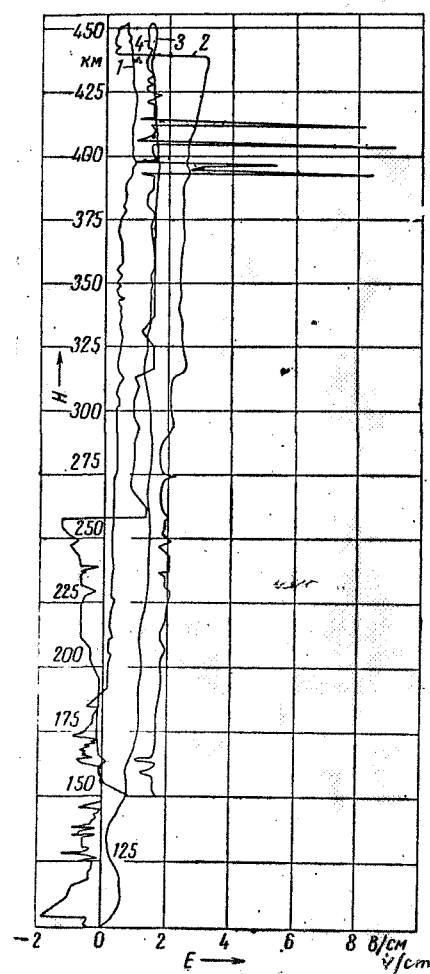


Fig. 3

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Consequently, the indicated discrepancies were not created by electron photoemission either. It is thus impossible to explain the results obtained without recourse to the effects, linked with the presence of an outer electrostatic field.

Examination of the experimental data plotted in Fig.1 and 3 shows that: 1) the electrostatic field strength oscillated within the 0.2 — 3 v/cm limits at the surface of the rocket flying in the ionosphere over most of its trajectory and corresponds to the negative charge of the rocket; 2) there are portions of the trajectory over which the rocket has a positive charge.

The value of the density of rocket's charge, computed on the basis of the obtained values of electrostatic field strength in the assumption that the rocket is a homogenous conducting cylinder, lies within the $5 \cdot 10^{-5} \text{ --- } 10^{-3}$ CGSE cm^{-2} limits.

Analysis of the results leads to the conclusion that in a series of cases an electrostatic field having no connection with rocket appearance in the ionosphere, is registered. The estimate of the magnitude of this outer field must be effected taking into account the specific phenomena occurring near the body, situated in a plasma, and must thus constitute a subject for a special consideration. During field strength measurements by the electrostatic fluxmeter method it is appropriate to apply the method, proposed in [2], which excludes to a significant

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degree the effects of interference currents with which part of the above-expounded results is connected.

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